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ABSTRACT

This study assessed the effects of varying degrees of elaboration in a prose format using computer-assisted instruction (CAI) with accompanying slides on posttest scores of college age learners. Four instructional treatments were used: control, embedded questions (TR1), computer generated feedback (TR2), and computer generated feedback with a visual rehearsal strategy (TR3). The control group had no elaboration method; for the other three treatments, elaboration was added to the script in increasing degrees. The subjects were 148 undergraduate students enrolled at the Altoona Campus of Penn State University. Materials used included a revised version of an instructional unit on the human heart developed by Dwyer in 1972. The instructional treatments were presented via an interactive video slide system and all subject responses during treatments were restricted to simple keyboard inputs. Each of the four instructional treatments contained the same instructional script, visuals, terminology labels, and arrows. The experimental design was a randomized posttest-only control group design although a 36-question pretest on physiology was used to label each treatment's subjects as high or low prior knowledge. It was concluded that subjects with high prior knowledge will consistently score better than subjects with low prior knowledge regardless of the kind or amount of elaboration, although both groups will benefit about the same from extra elaboration on tests of increasing cognitive difficulty. (12 references) (BBM)

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Title:

Effectiveness and Efficiency of Elaboration Using CAI

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IR 014578

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Educators are no longer content to place all their emphasis on the environment and the materials being used by students to guarantee success. If a teacher wishes to present a new concept, concern is now being focused on how best to present that concept to the student.

The popularity of the personal computer in the schools and in training facilities has made the possibility of personal education a reality. It is now possible to diagnose educational weaknesses and to prescribe certain types of remediation by way of the microcomputer; this, in turn, frees the teacher to deal with other students in class while the one having difficulty with an educational concept is learning through his or her interaction with the computer.

The most recent development of interactive video has made the computer even more versatile by pairing it with visuals provided by video cassette recorders or by slide systems. The combination of visuals and computer-generated lessons has made an already confusing situation even more so; educators must now make many more decisions about the best way to present their materials to learners. One of these teacher decisions deals with the amount of and with the kind of elaboration needed to provide a desired degree of student achievement while maintaining a realistic time frame for the instructional process. This study deals with the question of elaboration and with the efficiency of instruction in an attempt to find the best way to present material to learners.

The major weakness in the human information processing system is the short-term memory. There are two reasons for this weakness. First, the information is only present in short-term memory for about ten seconds (Murdock, 1961) unless it is rehearsed. Second, the limited capacity of the short-term memory extends from five to nine units of information (Miller, 1956, Simon, 1974). In order to transfer information from short-term memory to long-term memory it must be coded. Coding is a transformation process in which new information is integrated in various ways with known information. Having information in long-term memory is of no use if it cannot be retrieved. The ability to remember or retrieve information from long-term memory often depends on establishing a good retrieval cue.

Recognizing the limitations of short-term memory and the need for providing good retrieval cues is a prerequisite for good instruction. Any strategy or manipulation taking place during instruction can alter the cognitive structure and strengthen the pathway to the information to be learned and remembered. Mayer (1980) reports that researchers have recently referred to this as the learning strategy hypothesis: "Mathemagenic activities aimed at making the learner actively integrate new information with

existing knowledge affect the encoding, storage and eventual use of new material on performance tests" (p.770).

Many activities have been developed to help the learner integrate new information with existing knowledge, such as advance organizers, questioning strategies, feedback, and review procedures. Each of these activities provides for some degree of elaboration. Elaboration facilitates retrieval in two ways. First, it provides alternate retrieval pathways along which activation can spread (Anderson, 1976). Second, it provides extra information from which answers can be constructed (Reder, 1982). Although much research has been done with the above activities, questions still remain: (a) How much elaboration is needed to obtain the desired information? (b) Which mathemagenic activities provide the best means of gaining information? and (c) How much time should be spent on these activities to optimize information acquisition? This study added, in a step-like fashion, an increasing degree of elaboration to an instructional unit to determine what effect it would have on a posttest performance which would measure different levels of educational objectives. The activities which provided the elaboration were embedded questions, computer-generated feedback and overt rehearsal strategies.

The primary purpose of this investigation was to assess the effect of varying degrees of elaboration in a prose format using computer-assisted instruction with accompanying slides on post-test scores of college age learners.

By exploring elaboration strategies and their relationship with achievement, it was hypothesized that a significant contribution could be made to student achievement in terms of how people learn and how instruction could be organized so that retrieval of various types of knowledge might be facilitated.

This study was designed to test the following null hypotheses:

H1: There will be no differences in student achievement scores among the four elaboration formats (control, embedded questions (TR1), computer generated feedback (TR2), and computer generated feedback with a visual rehearsal strategy (TR3)) on tests measuring different educational objectives.

H2: There will be no interaction between prior knowledge levels and elaboration strategies

among students in the four treatment groups.

H3: There will be no differences in lesson completion time between types of elaboration strategies among students on tests measuring different educational objectives.

H4: There will be no difference in efficiency scores on tests measuring different educational objectives by treatment group.

Elaboration

Lindsay and Norman (1972) have argued for the need to retain information longer in short-term memory to enable it to be processed further before entering long-term memory. Retrieving and interpreting correctly the information from long-term memory can be as much a problem as getting the information into long-term memory originally. Cues given upon retrieval direct a person to the information or assist him/her in generating new cues or imposing additional structure on the information. The more interconnections between information, the more likely it is that a retrieval cue will be effective; memory is strengthened in proportion to the redundant means utilized to retrieve information. Elaboration is the term used for the process by which additional paths or links to information are made. Elaboration uses connections to prior knowledge, imaging and inferences, and features from the current context to improve memory by increasing the interconnections and imposing organization on the information (Anderson, 1980, pp. 217-218). Therefore, the more extra processing one does that results in additional, related, or redundant propositions, the better one will remember the processed information. Elaboration provides redundancy in the memory structure. Redundancy can be viewed as a safeguard against forgetting and an aid to fast retrieval.

The learning strategy hypothesis states that mathemagenic activities aimed at making the learner actively integrate new information with existing knowledge affect the encoding, storage, and eventual use of new material on performance tests (Mayer, 1980). Elaboration techniques play an important role in the learning strategy hypothesis. In general, past work in this area has followed one of two paradigms: associative elaboration techniques using artificial verbal materials or integrative and comparative elaboration techniques using real world materials. The associative elaboration procedure involves making a visual and/or verbal association between the two stimuli. Comparative elaboration occurs when a learner actively explains the relation

between two concepts in the text; integrative elaboration occurs when the learner explains the relation between a concept in the text and some concepts already in the learner's memory. These techniques differ from associative elaboration mainly in degree; they require more than a single mnemonic sentence or image.

In a study by Mayer (1980), the elaboration techniques were used to enhance learning of new technical information. His results provided consistent evidence that elaboration techniques can influence the outcome of learning, even when the material to be learned is in instructional text. His results were strongest for low-ability subjects suggesting the need to ensure integration encoding processes via instructional manipulation is strongest for learners who would not normally use these strategies for meaningful learning. Thus there is positive support for the learning strategy hypothesis, which states that how the learner encodes the material influences what is learned.

Because appropriate prior knowledge and practice in using that knowledge to make meaningful relationships are essential for elaborative activities the use of elaboration may not be effective in improving learning and enhancing retention and may even decrease achievement (Bransford, Stein, & Vye, 1982).

The rehearsal strategies used in this study were designed to provide various degrees of elaboration by focusing attention and allowing time for incoming information to remain in short-term memory long enough to be elaborated upon and encoded for long-term memory.

In this study, the subjects were 148 undergraduate students (69 males, 79 females) enrolled at the Altoona Campus of Penn State University.

The instructional content developed by Dwyer (1972) consisted of a 2,000 word instructional unit describing the parts of the human heart, the internal functions of those parts, and the interrelated simultaneous functioning of those parts with 37 visuals of the heart. This was later revised by streamlining the presentation and reducing the amount of incidental content. The revised script contained approximately 1800 words and utilized 19 visuals of the heart. This study used the approximately 1800 word revised script, but employed 33 of the original 37 2x2 slides from the original 2000 word Dwyer instructional unit. The visuals employed consisted of simple, colored line drawings depicting the form and relative locations of the parts of the heart as they are mentioned in the instruction. The illustrations featured printed words and arrows focusing student attention on the critical parts being described. The visuals were comprised of blue lines on a

pink background, and color was used solely to provide color contrast. An example of the visuals used in the instructional unit is shown in Figure 1.

The instructional treatments were presented via an interactive video slide system comprised of the following equipment: an Apple IIe microcomputer, a color monitor with 24 lines and 40 columns, and a Telex Caramate 4000 slide projection system. All subject responses during instruction were restricted to simple keyboard inputs, with the exception of treatment three where an overt visual rehearsal method was used in addition to the computer responses.

The Verbal Tests

Two of the four posttests developed by Dwyer (1972) and revised by Lamberski (1980) were utilized in this study. A description of the two tests as adapted from Dwyer (1978, pp. 45-47) follows.

Drawing Test.

The objective of the drawing test was to evaluate student ability to construct and/or reproduce items in their appropriate context. The drawing test (N = 20 items) provided the students with a numbered list of terms, for example, superior vena cava, aorta, tricuspid valve, and pulmonary vein, corresponding to the parts of the heart discussed in the instructional presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents. An average reliability coefficient of .83 was computed by Dwyer (1978, p. 47) using the Kuder-Richardson Formula 20 Reliability coefficient on a random sampling of previous studies.

The original drawing test was revised slightly in this study to test for the effects of cued and uncued responses. Instead of giving the learner the 20 terms to identify on the heart drawing, only 10 were given and the learner was asked to provide the missing 10 terms from memory, then locate them on the heart drawing. The part of the test having the 10 terms given to the learner was referred to as the cued recall drawing test P1 and the part of the test having no given terms was referred to as the free recall drawing test P2.

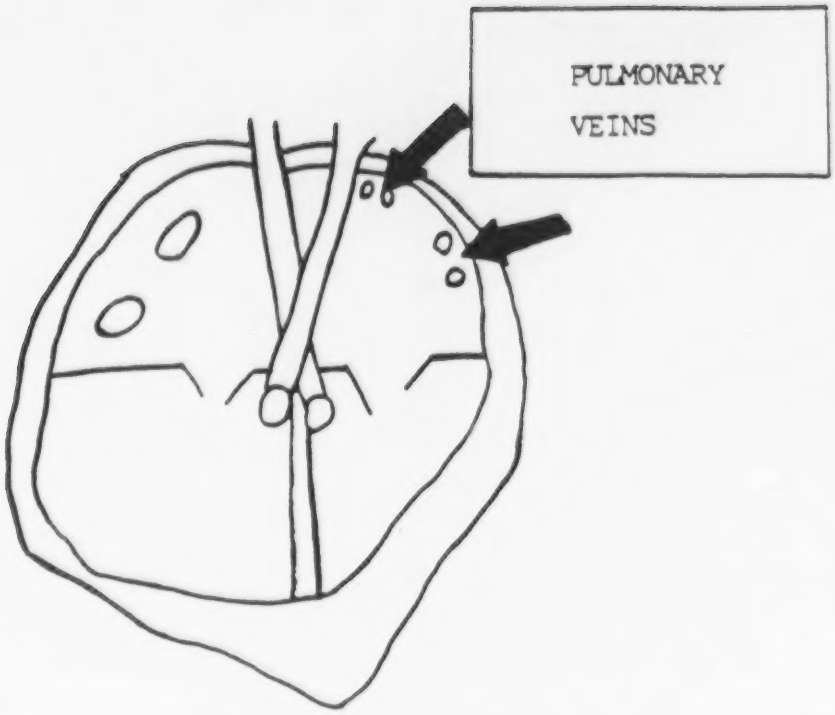


Figure 1. Sample of visuals used in the instructional unit.

Comprehension Test.

The comprehension test consisted of 20 multiple-choice items. Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to determine the position of other specified parts of the heart at the same time. This test required the students to have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure the ability of the individual to use the information being received to explain some other phenomenon. An average reliability of .77 was computed by Dwyer (1978, p. 47) using the Kuder-Richardson Formula 20 Reliability coefficient on a random sampling of previous studies.

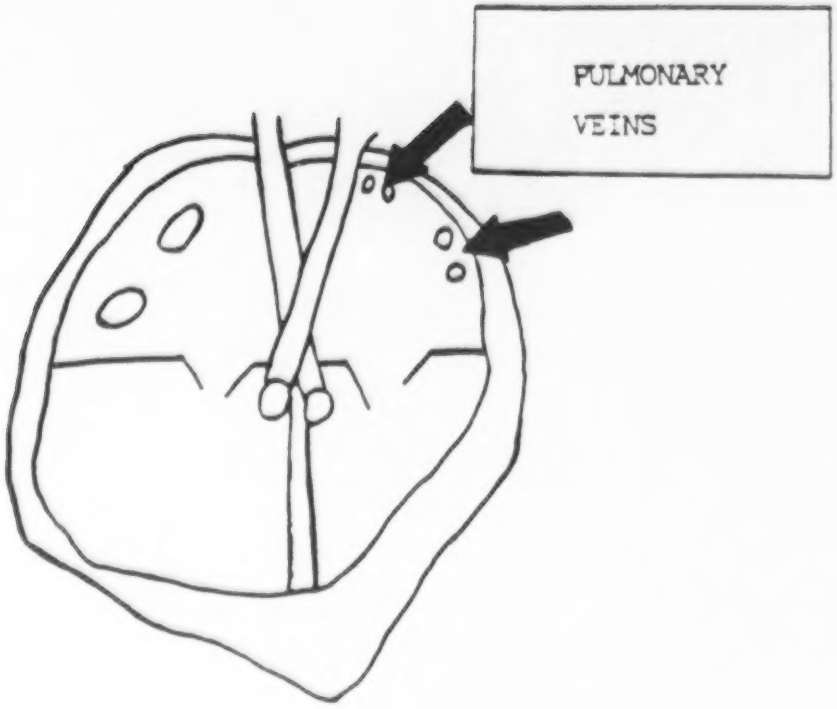
All subjects of this study were given the above three posttests at the completion of the lesson.

The Instructional Treatments

Each of the four instructional treatments in this study contained the same instructional script, visuals, terminology labels, and arrows. The treatments differed in the degree of elaboration employed. The four degrees of elaboration are identified by the treatment number. The control group had no elaboration method; Figure 2 is representative of the presentation received by the control group.

For each of the other three treatments, elaboration was added to the script in increasing degrees. Each of the elaboration treatments had questions added to the script. A pilot test of the heart material conducted during the Summer term 1987 at the Altoona Campus of Penn State University provided 12 areas within the script where students were experiencing difficulty in comprehending the information being presented. The content presented in these 12 areas of the script were found to have been evaluated by a total of 18 questions on the comprehension and drawing tests. Each of these questions had at least 60 percent of the student responses incorrect on the pilot test. Focusing on these 12 areas, questions possessing increasing degrees of elaboration were embedded in the appropriate sections of the script.

The first treatment, TR1, embedded questions at the end of each identified section which required the learner to respond by typing his response on the computer. All responses were accepted by the computer, and no feedback was given as to the correctness of the response. Pressing RETURN after typing in the response caused the computer to proceed to the next part of the lesson.



RETURNING FROM THE LUNGS, THE BLOOD ENTERS THE HEART THROUGH FOUR PULMONARY VEINS AND COLLECTS IN THE LEFT AURICLE; THESE VEIN OPENINGS LIKE THE VENA CAVAS, HAVE NO VALVES. THE LEFT AURICLE THEN CONTRACTS WHEN IT IS FULL, SQUEEZING BLOOD THROUGH THE MITRAL VALVE INTO THE LEFT VENTRICLE.

PRESS RETURN TO CONTINUE.

Figure 2. Sample screen from the control treatment having no elaboration added.

See Figure 3 for an example of the treatment one script with added questions.

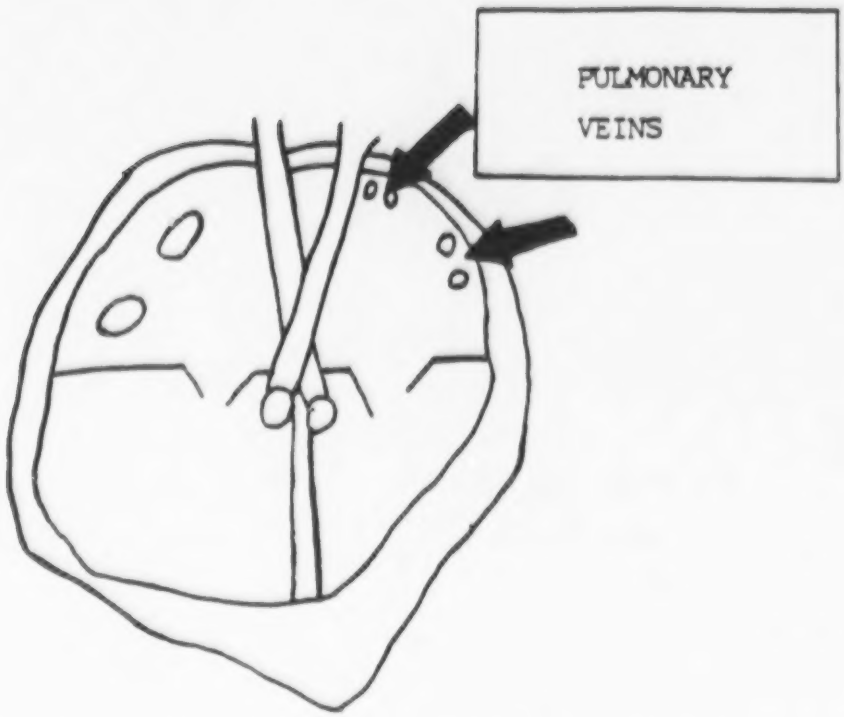
The second treatment, TR2, added the same questions at the end of each identified section as did treatment one, but four response options were provided (A,B,C,D) with one of the choices being the correct answer and the other three acting as distractors. The learner pressed the letter of his choice and then the RETURN key. The response was evaluated by the computer and feedback was provided as to the correctness of the response to the learner. If the correct answer was given the learner was told it was correct and additional information on that particular topic was given to provide further elaboration. If an incorrect response was given the learner was told it was incorrect, why it was incorrect, and what the correct answer should have been. In giving the correct response the same basic elaboration was provided as was given to the learner who identified the correct answer. See Figure 4 for an example of the treatment two script with multiple-choice questions and Figure 5 for a sample of the elaboration provided as feedback.

The third treatment, TR3, had the same question structure as the second treatment, but with still further elaboration provided by an overt visual rehearsal strategy. This rehearsal strategy required the students to shade with colored pencils the specified parts and functions of the heart. The parts and functions to be shaded corresponded to, as closely as possible, the words that were used to answer the questions in treatments one and two. The shading took place on a separate sheet of paper with three provided drawings of the heart similar to those appearing on the lesson slides. See Figure 6 for an example of the treatment three script and Figure 7 for the heart drawings used in the overt visual rehearsal strategy.

Design

The experimental design of this study was a randomized posttest-only control group design. The variables manipulated in the study were the degree of elaboration present in the treatments. There were three treatments possessing different degrees of elaboration and one control treatment which utilized no elaboration, resulting in a total of four levels of the elaboration variable. The dependent variables were the achievement scores on the Comprehension posttest, the two parts of the Drawing posttest, and time-on-instruction.

The physiology 36 question pretest was used to label each treatment's subjects as high or low prior knowledge level. This was accomplished by designating those students whose score was above or equal to the general median score (21) to have high



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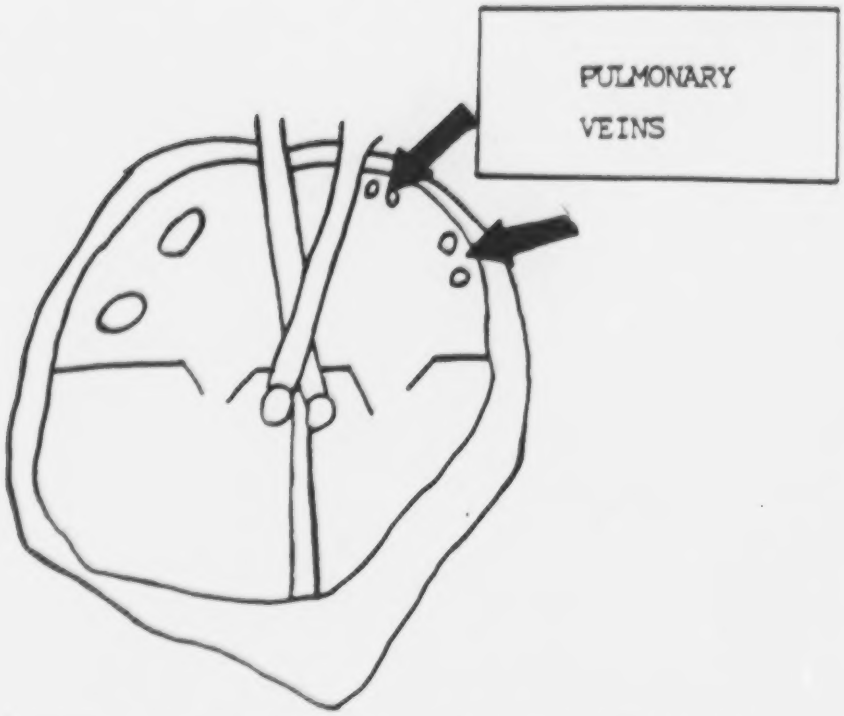
(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _____ VEINS.

TYPE RESPONSE THEN PRESS RETURN.

Figure 3. Sample screen from treatment one with questions added, but no feedback.



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(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _____ VEINS.

TYPE LETTER OF CHOICE THEN PRESS RETURN.

A) MITRAL
B) VENA CAVA
C) AURICULAR
D) PULMONARY

Figure 4. Sample screen from treatment two with multiple choice questions added and computer generated feedback.

Question #7 - As the blood returns to the heart from the lungs, it enters the heart through the _____ veins.

A) Mitral
B) Vena Cava
C) Auricular
D) Pulmonary

The correct response (D) Pulmonary would result in the following feedback on the computer screen:

CORRECT:
THE "NEW" CLEANSED AND OXYGENATED BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS.

Incorrect response (A) Mitral would have the following feedback on the screen:

INCORRECT:
MITRAL REFERS TO THE VALVE OPENING BETWEEN THE LEFT AURICLE AND THE LEFT VENTRICLE.

REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

Incorrect response (B) Vena Cava would have the following feedback on the screen:

INCORRECT!
THE VENA CAVAS DO ALLOW BLOOD TO ENTER THE HEART FROM ALL PARTS OF THE BODY, BUT NOT FROM THE LUNGS.

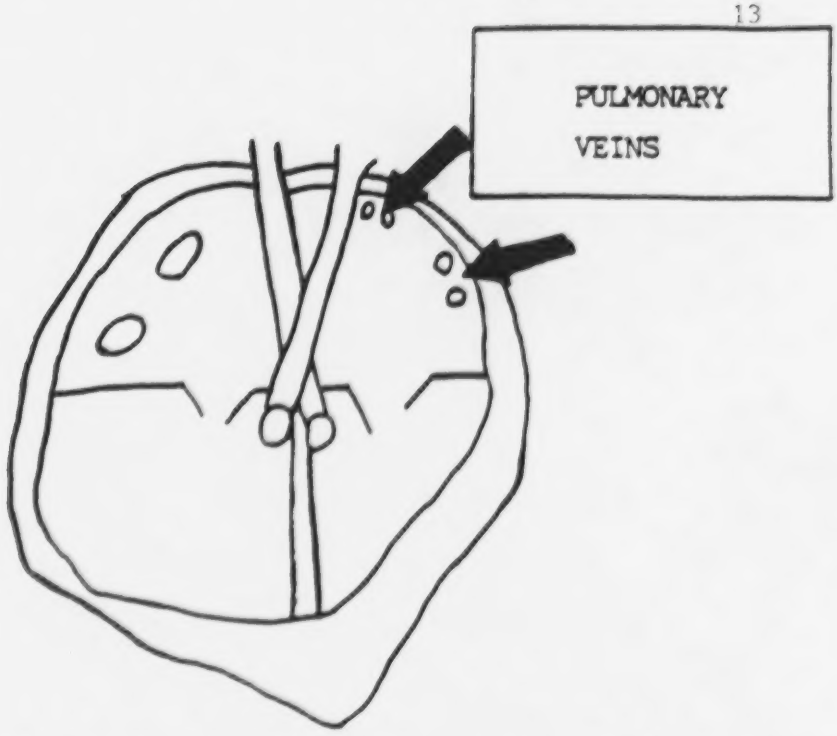
REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

Incorrect response (C) Auricular would have the following feedback on the screen:

INCORRECT:
ALTHOUGH BLOOD RETURNING TO THE HEART FROM THE LUNGS DOES ENTER THE LEFT AURICLE IT ENTERS THROUGH THE PULMONARY VEINS.

REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

Figure 5. Sample of the elaboration provided as feedback to the responses given in treatments two and three.



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* COLOR THE PULMONARY VEINS BLACK.

* COLOR THE MITRAL VALVE YELLOW.

(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _____ VEINS.

TYPE LETTER OF CHOICE THEN PRESS RETURN.

A) MITRAL
B) VENA CAVA
C) AURICULAR
D) PULMONARY

Figure 6. Sample screen from treatment three with the overt visual rehearsal strategy added to the multiple choice questions with feedback.

DRAWING PRACTICE FOR TREATMENT #3

14

NAME

FIGURE #1

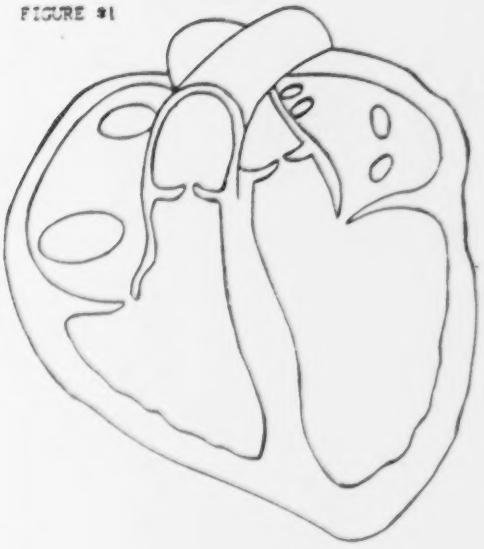
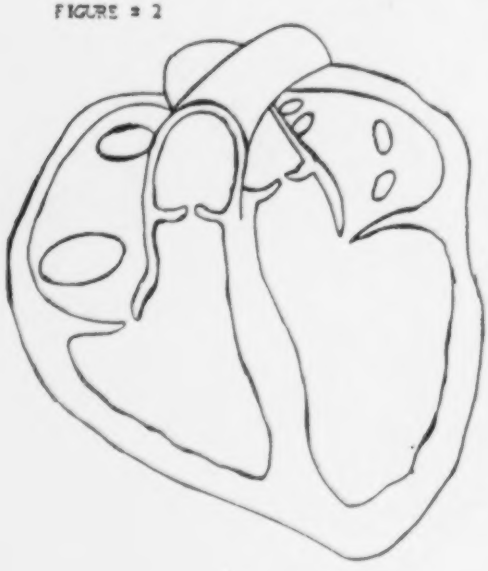


FIGURE # 2



*** NOTE *** Coloring does not have to be fancy; just roughly outline the part of the heart that is described. This is not a test of your artistic abilities!!

FIGURE # 3

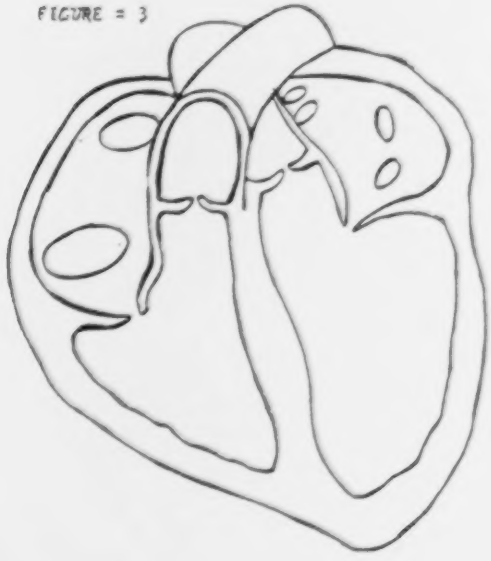


Figure 7. Heart drawings used in overt visual rehearsal strategy in treatment three.

prior knowledge level and those below the mean to have a low prior knowledge level.

Data Analysis Procedures

The computer program SAS (Statistical Analysis System) available from the Computation Center at Penn State University was used to do the statistical analysis on the data collected in this study. Using SAS-GLM (General Linear Model), since each cell had different numbers of subjects, a multivariate analysis of variance, MANOVA, was run to test for an overall effect. A series of univariate ANOVAs was then used for one-factor and two-factor analysis of variance as a follow up to a significant MANOVA.

To test main effects when there was no interaction, the conservative Tukey Studentized Range (HSD) Test was used to compare pairs of means.The Kuder-Richardson 20 was used to generate the reliability coefficient for the multiple-choice tests.

RESULTS

The Physiology Test

All subjects completed the physiology pretest prior to receiving their respective instructional unit. The test was used to verify that proper randomization techniques had been used to assign treatments to subjects by assuring homogeneity of the subjects with respect to prior knowledge related to the instructional unit. The test was also used to determine the prior knowledge level of the subjects.

Stages of Analysis

The general analysis of the collected data was done in two separate stages with each stage examining a different aspect of the study. In the first stage a MANOVA was run to check for overall group and prior knowledge effects and to check for possible group by prior knowledge interactions on the criterion tests for the four treatment groups. If significance was found at the .05 alpha level, then follow-up tests using univariate ANOVAs and Tukey's HSD test were run. If no significant difference was found in the first stage the analysis was terminated.

In the second stage, the concept of efficiency was introduced with each subject's scores on the criterion tests being divided by his total time-on-instruction to provide an efficiency score for each test. A MANOVA was then run to check

for overall group and prior knowledge effects and to look for possible group by prior knowledge interactions using these efficiency scores. Significant results were then analyzed further using follow-up ANOVAs and Tukey HSD tests.

Findings

Time-on-Instruction

Finding that treatment TR3 had significantly more time-on-instruction was no surprise considering the extra time spent in doing the visual rehearsal strategy in treatment TR3. Treatments TR1 and TR2, although not taking nearly the time of TR3, still spent significantly more time-on-instruction than the Control group. A significant difference in time spent on instruction was expected with the increasing degree of elaboration taking more time to complete. In all cases this additional time spent on instruction resulted in higher achievement scores on all the criterion tests. The decision to adopt a treatment taking more time to complete would depend on the degree of mastery required and the time available for instruction.

The Comprehension Test

Although the first stage analysis found a significant difference in achievement among the four treatment groups there was no significant difference in achievement on the comprehension test. The increasing degrees of elaboration and the different types of elaboration did not increase the achievement on the comprehension test significantly.

The introduction of prior knowledge levels in the analysis did find, however, that high prior knowledge subjects scored significantly higher than low prior knowledge subjects on the comprehension test. It was felt that increasing the amount of elaboration would help decrease the significant difference between achievement scores of the two prior knowledge levels, but this did not occur. A possible explanation for this failure to overcome these existing differences might be the difficulty of the test material. The mean score on the comprehension test was 11.392 out of a possible 20 with the high prior knowledge subjects having a mean score of 12.432 and the low prior knowledge subjects having a mean score of 10.351. With so much room for improvement it was unlikely the high prior knowledge subjects experienced a ceiling effect which would have allowed the lower prior knowledge subjects to close the gap between their scores.

The mean scores of the high prior knowledge subjects on the comprehension test ranged from a low of 12.083 in treatment group TR3 to a high of 12.824 in treatment group TR2, a difference of 0.741. The range for the low prior knowledge subjects was from 8.800 in the Control group to a high of 11.313 in treatment group TR3, a difference of 2.513. Although the difference in treatment group scores for the high and low prior knowledge subjects were not statistically significant, they did suggest that the increasing degrees of elaboration helped the low prior knowledge subjects more than the high prior knowledge subjects on the comprehension test.

Although not a significant difference, the high prior knowledge subjects spent on average 36.837 minutes on instruction while the low prior knowledge subjects spent on average 33.946 minutes on instruction. It would seem that the high prior knowledge subjects spent at least as much time on instruction as the low prior knowledge subjects, but they were unable to improve their achievement significantly on the comprehension test regardless of the amount or kind of elaboration that was used.

A further consideration might be that the six questions that were elaborated upon in the comprehension test were concerned with functions of certain parts of the heart at specific times, but the increased elaboration in treatment TR3 was visually oriented and more likely to effect achievement on the drawing tests than on the comprehension test.

The consideration of efficiency scores in the second stage of the analysis also showed the achievement of the high prior knowledge subjects to be significantly better than the low prior knowledge subjects on the comprehension test. This result pointed out that any difference in time spent on instruction between the two prior knowledge levels was not a significant factor in their achievement scores. As mentioned earlier, the high prior knowledge subjects did spend more time (approximately three minutes) on instruction than did the low prior knowledge subjects. Since efficiency scores were determined by dividing each test score by total time-on-instruction for each subject, a significant difference in time-on-instruction between two subjects having comparable raw scores would result in the subject who spent more time-on-instruction having a lower efficiency score. Since the high prior knowledge subjects still scored significantly better than the low prior knowledge subjects when efficiency scores were used, this would seem to imply that achievement increased with time-on-instruction so that the overall ratio of achievement score to time-on-instruction remained about the same for both prior knowledge groups.

Using efficiency scores resulted in the first significant difference between achievement of the treatment groups on the comprehension test. No difference was found when raw scores were

used, but with the efficiency scores the treatment with the most elaboration TR3 scored significantly lower than all the other treatments. This result was not surprising considering the mean increase in achievement from the Control group to TR3 on the comprehension test was 0.98, but the amount of time spent on instruction more than doubled.

Although the difference in time-on-instruction between the Control group and treatment groups TR2 and TR3 was significant, their raw scores were not, which resulted in the Control group efficiency score being significantly higher than the efficiency scores of treatment groups TR2 and TR3. The fact that no significant difference in time-on-instruction was found between treatment groups TR1 and TR2 could help explain why no difference in achievement was found between these treatments when efficiency scores were used. The significance of these results was found in the realization that the considerable amount of time spent on instruction in treatment TR3 not only failed to increase achievement proportionately on the comprehension test but also resulted in a lower efficiency score. This finding would seem to suggest that improving achievement is not simply a matter of spending more time-on-instruction. Another notable point was that although the difference in time spent on instruction was significant between Control and treatment TR1, there was no significant difference between their efficiency scores which would imply achievement increased sufficiently in treatment TR1 to offset the additional time spent. A similar observation would apply for treatments TR1 and TR2. This would suggest that the increase in achievement on the comprehension test gained by increasing the degrees of elaboration in the first three treatments was a worthwhile use of time spent on instruction. Treatment TR3 did not satisfy this condition because its considerable increase in time-on-instruction was not offset by a comparable increase in achievement on the comprehension test.

One final point on the comprehension test results would be to consider the fact that only 6 question areas received elaboration out of the 20 questions on the test. It would seem logical to assume that any increase in achievement on these 6 questions would not have the same effect as increases in the 6 questions elaborated upon in the drawing tests which have only 10 questions each.

Drawing Test P1

The significant difference in achievement between the treatment groups on Drawing test P1 found in the first stage of the analysis showed treatment TR3 to be significantly better than the other treatments. Since treatment TR3 had a visual rehearsal

strategy which was directly related to the information tested in Drawing test P1 it was not surprising that this treatment scored significantly better than the other treatments which did not have this additional visual component. Although the mean achievement scores in the first two treatments TR1 and TR2 were not significantly higher than the score of the Control group on Drawing test P1 they were higher (Control 5.11 to TR1 and TR2 5.49). This would seem to possibly indicate that the elaboration in treatments TR1 and TR2, while having some effect, did not effect achievement like treatment TR3 (mean score 7.55 out of 10). Previous research has shown that visuals such as the line drawings in this study used in conjunction with prose instruction do improve student learning and consequent ability to reproduce the visuals in a drawing test. However, in a study using similar material and treatments by Dwyer, 1984 no significant difference was found on the drawing test. The fact that Drawing test P1 was a test of cued recall evaluating the subject's ability to construct and/or reproduce items in their appropriate context was probably the main reason why treatments TR1 and TR2 did not show much effect since they did not concentrate on the visual aspects of the heart material. The increased elaboration in TR2 over TR1 was of little consequence as the content elaborated upon was not tested in P1.

As with the Comprehension test, the high prior knowledge subjects did significantly better than the low prior knowledge subjects on Drawing test P1. The difference in mean achievement scores for the high and low prior knowledge subjects were almost identical for each of the treatments showing that the elaboration had the same effect on both prior knowledge levels on Drawing test P1. Both prior knowledge levels increased their achievement as the amount of elaboration increased on the targeted material.

Using efficiency scores resulted in the Control group achieving significantly better than treatment TR3 on Drawing test P1, but no difference was found between the other treatments. This seemed to validate the earlier findings that treatments TR1 and TR2 had very little effect on achievement on Drawing test P1. The earlier mentioned study done by Dwyer, 1984 used the same content and similar tests but found no significant difference on the drawing test. The major difference between her study and this one was the use of computer-generated feedback that was also included in TR3. Perhaps this elaboration while not very effective on its own (TR2) may interact with the overt visual rehearsal strategy to produce an effective means of presenting the material.

Drawing Test P2

The only difference between Drawing tests P1 and P2 was the cues present in P1 were absent in P2. The results were similar in that treatment TR3 was again significantly better than the other treatment groups when raw scores were used and considerably worse than the other groups when efficiency scores were used. The similarity ends when the treatments are compared for each test. The achievement on Drawing test P2 was the only one where each increase in elaboration resulted in a noticeable increase in achievement from the previous treatment. Achievement on the Comprehension test actually dropped in treatment TR2 while achievement in Drawing test P1 showed practically no increase from the Control to treatment TR2. Perhaps the elaboration done in treatments TR1 and TR2 while not improving achievement on Drawing test P1 with cued recall did provide the needed help in Drawing test P2 where recall cues were not provided. The rehearsal strategy of typing responses and answering questions present in TR1 and TR2 may have helped to further implant these terms into long-term memory. The achievement of the prior knowledge levels on Drawing test P2 were similar to those on Drawing test P1 with the high prior knowledge subjects having approximately the same difference in achievement over the low prior knowledge subjects in each treatment. The significance of Drawing test P2 seems to lie in the fact that it did not provide cues to help the subject recall the names for the parts of the heart so that they could then be located on the drawing of the heart. Because these cues were not given the subject had to remember them from the given instruction and at this point the additional elaboration given in the treatments may have provided some cues to help the subject retrieve this information from long-term memory.

Summary of Results

The hypotheses presented in this study and the results for each are as follows:

H1: There will be an insignificant difference among achievement scores of the four presentation formats, control, embedded questions (TR1), computer-generated feedback (TR2), and computer-generated feedback with a visual rehearsal strategy (TR3).

This hypothesis was rejected as a significant difference was found between the achievement of the four presentation formats

with treatment TR3 having the highest achievement scores on all three criterion tests.

H2: There will be an insignificant interaction between prior knowledge level and type of rehearsal strategy among students in the four treatment groups.

This hypothesis was retained as the subjects with high prior knowledge level achieved significantly higher scores on all the criterion tests than the low prior knowledge subjects regardless of the treatment.

H3: There will be insignificant differences in lesson completion time between types of rehearsal strategies among students on tests measuring different educational objectives.

This hypothesis was rejected as a significant difference was found between the time-on-instruction for each of the treatments with TR3 > TR2 > TR1 > Control. As the degree of elaboration increased the subjects spent more time-on-instruction even though the instruction was self-paced.

H4: There will be an insignificant difference in efficiency scores on tests measuring different educational objectives by treatment group.

This hypothesis was also rejected. As the degree of elaboration increased the time-on-instruction also increased yielding a significant increase in achievement on the three criterion tests. Although the test scores did increase significantly, the efficiency scores of each treatment group diminished as the amount of time spent on instruction increased for each of the criterion tests. Control > TR1 > TR2 > TR3.

Conclusions

The results of this study have provided some interesting points for consideration before planning any instruction using increasing degrees of elaboration. As with most research these findings can only suggest a possible path to follow when preparing instruction, but a path nonetheless.

The fact that elaboration works seems to be rather clearly shown. The effect of elaboration on high prior knowledge subjects can be both helpful and harmful depending on the circumstances of the instruction. If the content is rather easy the time taken for elaboration is probably not time well spent for the high prior knowledge subject and could lead to boredom and a subsequent decrease in achievement. The effect of elaboration on the low

prior knowledge subject for easier material is much more positive as it allows this type learner to acquire material that would be missed without the extra elaboration. The extra time spent on instruction because of the elaboration also helps the low prior knowledge learner to better organize the material in short-term memory which results in better retention and retrieval from long-term memory. With harder material the effect of elaboration is going to depend to a large degree on the amount of elaboration and time spent on the instruction with the lower prior knowledge learners requiring considerably more of both than the higher prior knowledge learners.

The efficiency of instruction using elaboration will generally be rather poor as more elaboration goes hand in hand with more time spent on instruction. The results of this study seemed to indicate that the gains in achievement were not commensurate with the amount of time spent on the instruction.

Subjects with high prior knowledge will consistently score better than subjects with low prior knowledge regardless of the kind or amount of elaboration. On tests of increasing cognitive difficulty both groups will benefit about the same from the extra elaboration.

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